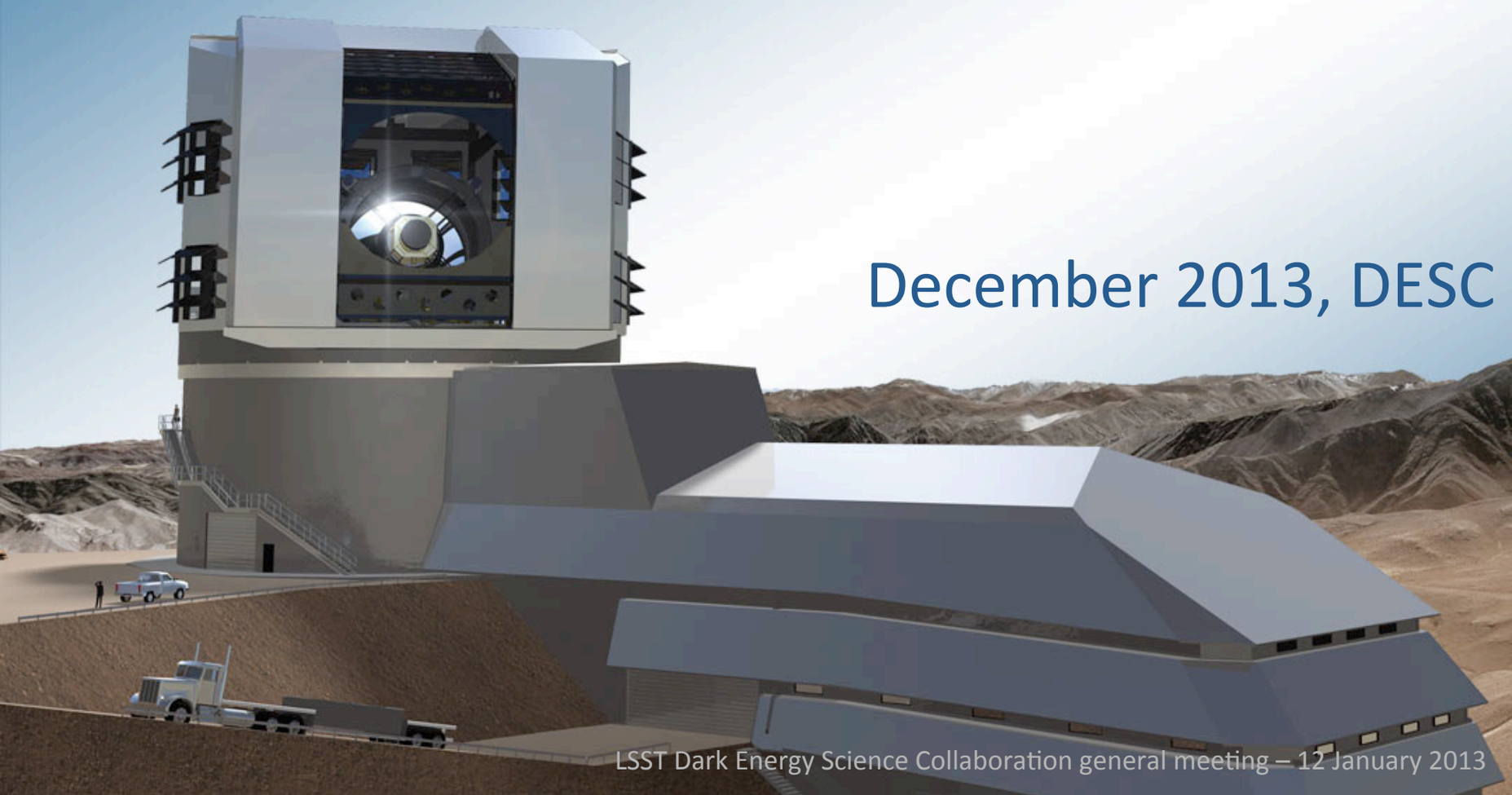
- Pre-Pittsburgh Activities
- Pittsburgh Activies
- Future Plans

LSST DESC
Dark Energy Science Collaboration

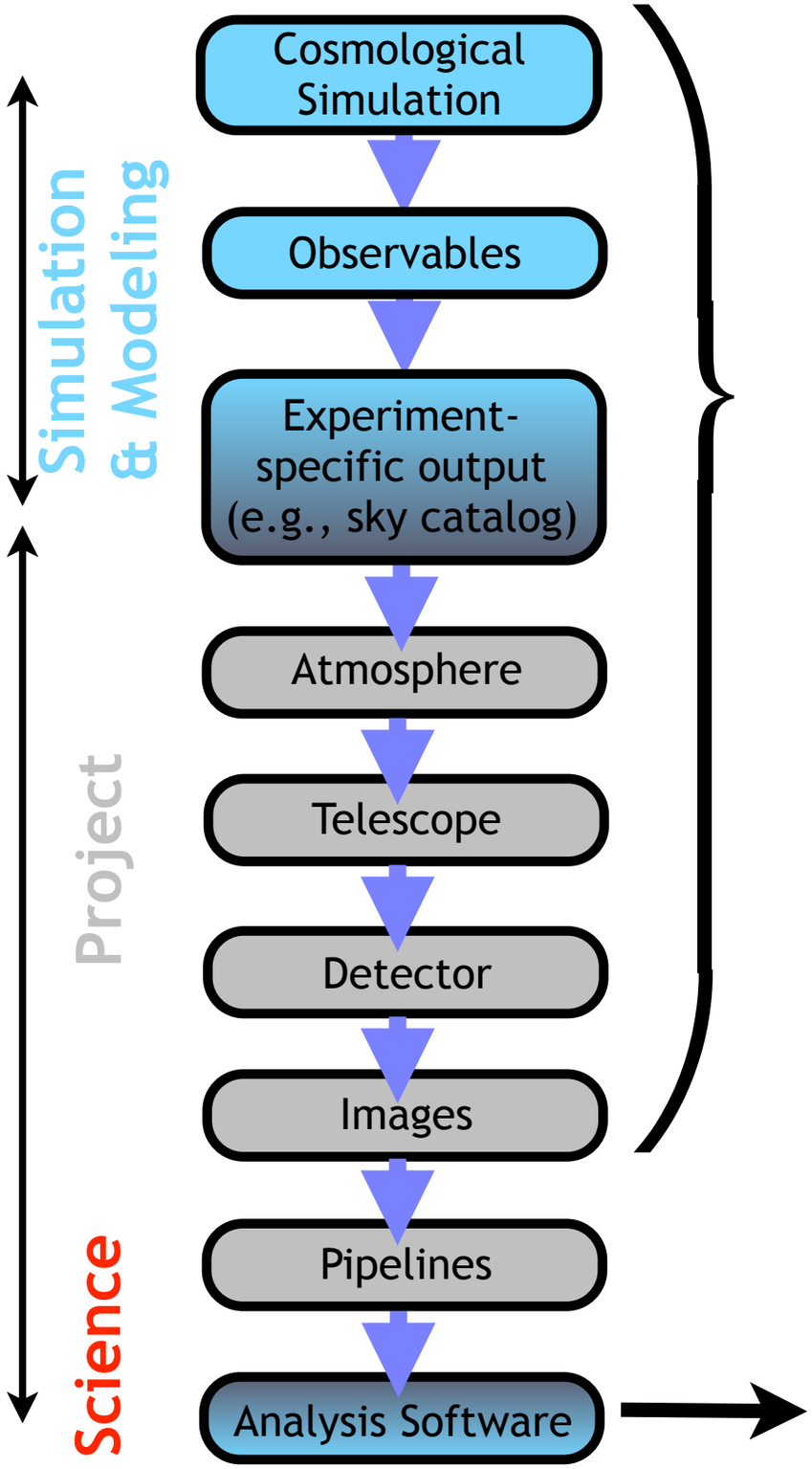
DESC Cosmological Simulation Working Group Summary Report

Katrin Heitmann

December 2013, DESC Pittsburgh Meeting

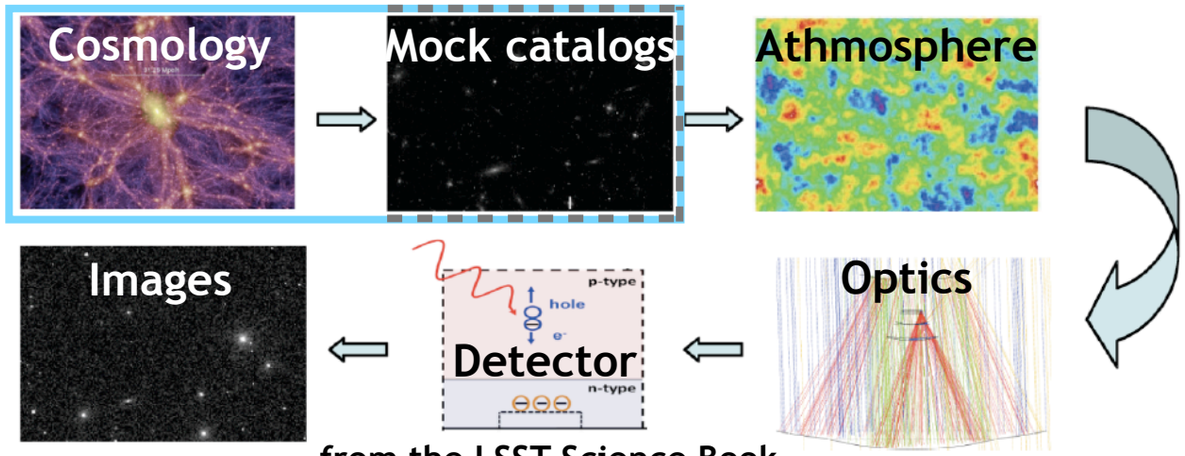


Roles of Cosmological Simulations in DE Survey Science



(1) CosmoSim as Input to CatSim/PhoSim (Wed)

- First part of end-to-end simulation
- Control of systematics



from the LSST Science Book

Task 5.9.1, H1
Task 5.9.2, H1-H3

(2) Solving the Inverse Problem, Extracting Dark Energy Science (Thursday/Friday)

- Fast, very accurate predictions tools (emulators) for physics and observables of interest
- Astrophysical systematics, e.g. baryonic effects
- Predictions for covariances

Task 5.9.1, H2-H3

Pre-Pittsburgh Activities I: Joint WG Workshop

- **February 2013: Joint Theory/Combined Probes + Simulation Group Workshop at Argonne**
  - 19 participants + 2 remote participants from 8 institutions
- **Discussion Topics**
  - Modified gravity and simulations thereof
  - Modeling of redshift space distortions
  - Covariance matrices
  - Intrinsic Alignments
  - Baryonic effects on the matter power spectrum
- **Four of these topics were picked up during this meeting again**
- **Write-up about the meeting posted on the wiki:**

https://confluence.slac.stanford.edu/display/LSSTDESC/Meeting+at+SLAC%2C+January+10-12%2C+2013

Pre-Pittsburgh Activities II: DESC Relevant Papers published by the Working Group

- **Task 5.9.1-H-1: Simulations for mock catalog generation**
  - X. Xu, S. Ho, H. Trac, J. Schneider, P. Barnabas, M. Ntampaka: ***First Look at Creating Mock Catalogs with Machine Learning Techniques***, ApJ 772 (2013), **Discussed on Wednesday during CoSim session**
- **Task 5.9.1-H-2: Data analysis and prediction tools**
  - C.B. Morrison, M.D. Schneider, ***On estimating cosmology-dependent covariance matrices,*** JCAP11, 009 (2013), **Discussed on Friday**
  - S. Dodelson, M.D. Schneider, ***The effect of covariance estimator error on cosmological parameter constraints***, Phys. Rev. D88, 063537 (2013), **Discussed on Friday**
  - A. Updahye, R. Biswas, A. Pope, K. Heitmann, S. Habib, H. Finkel, N. Frontiere, ***Large-Scale Structure Formation with Massive Neutrinos and Dynamical Dark Energy,*** Phys. Rev. D, accepted for publication, **Discussed on Thursday during Joint Theory/Simulation cross WG session, also highlight project**

https://confluence.slac.stanford.edu/display/LSSTDESC/Papers

Pre-Pittsburgh Activities III: Mock Catalog and Requirements Document

- **Started write-up that covers three topics:**
- **Mock catalog generation efforts**
  - Currently four efforts listed, complementary approaches
  - For each effort: approach, status, possible shortcomings and planned mitigations
- **Requirements from the Working Groups and as Input to CatSim/PhoSim**
- **Validation: Comparison of mocks with sky observations**
- **Fourth topic to be added: currently available simulations**
- **Focus of Wednesday session, document will be posted on the wiki very soon, input from everybody welcome!**

Mock Catalog Generation Efforts

- **CMU Effort:**
  - S. Ho, A. Klein, Z. Liu, R. Mandelbaum, J. Oliver, B. Pozcos, J. Schneider, H. Trac, X. Xu et al.
  - Machine learning techniques used to populate dark matter simulations with galaxies, use halo information beyond mass
  - Machine learning techniques used generate nonlinear density fields from initial conditions, ``train'' 2LPT on high-res N-body simulations, promising method to generate many mocks very fast, covariances!
- **JPL Effort:**
  - A. Kiessling
  - SUNGLASS: Simulated UNiverses for Gravitational Lensing Analysis and Shear Surveys
  - Medium resolution simulations, focus on topics such as covariance matrices for weak lensing
  - Next: realistic galaxy properties via Galacticus, intrinsic alignment modeling

Mock Catalog Generation Efforts

- **Stanford/SLAC/Michigan/Chicago Effort:**
  - R. Wechsler, M. Busha, M. Becker, Y. Lu, R. Reddick, E. Rykoff, G. Evrard, A. Kravtsov et al.
  - Three different approaches: (i) ADDGALS, based on medium resolution simulations, large volumes, (ii) Subhalo abundance matching, based on high resolution simulations, smaller volumes, (iii) semi-analytic modeling (SAM)
  - Many different uses of mocks across all working groups
- **ABC Effort (Argonne/Berkeley/Carnegie):**
  - A. Benson, R. Biswas, J. Cohn, N. Frontiere, B. Gutierrez, S. Habib, K. Heitmann, E. Kovacs, E. Lawrence, T. Malik, A. Pope, E. Rangel, M. White
  - Two approaches: (i) HODs on large volume simulations, (ii) SAM on high resolution simulations using Galacticus
  - For SAMs two major efforts: (i) Emulator approach to explore parameter settings; (ii) Connection to CatSim/PhoSim, e.g database development, required galaxy properties etc.

Mocks and Simulations Currently Available or in Progress

- **Current LSST project mock: Based on Millennium simulations, 16 sq deg, shortcoming: no shear, this possibly available from S. Hilbert, need to explore this more**
- **SUNGLASS lightcone mocks, 0<z<2, contain shear, convergence, and positions, 7 different cosmologies, 450 realizations (Kiessling)**
- **2 cosmologies, 5,000 sq deg for each mock, current focus on DES, more cosmologies are currently being processed (Wechsler et al)**
- **WMAP-7 cosmology, SAMs, LSST-Deep Drilling Field (Munoz-Arancibia et al)**
- **Many large N-body simulations available:**
  - Trac et al: 2 Gpc/h, 4096^3 particles, halo catalogs, merger trees, lightcone out to z=6, currently running
  - Argonne: 1.5 Gpc/h, 3200^3 particles, halo catalogs, 6 cosmologies (LCDM, w0-wa, neutrinos), 100 snapshots starting at z=10; 4 Gpc/h, 4096^3 particles, 6 cosmologies (Planck, WMAP-7, and variants around those), snapshots starting at z=4; 3 Gpc/h, 10240^3 particles, currently at z=0.4, ~85 snapshots

Working Group Requirements

- **Lots of information collected by Debbie Bard**
- **Questions asked:**
  - What quantities do you care about most in simulation mocks?
  - What (if any) range of cosmologies would be useful?
  - What is the time scale by when those mocks are needed?
- **Answers from: LSS, WL, Clusters, Strong Lensing, SN, Photo-z**
- **Most useful in short term: small (~10 sq deg) volumes with great details (several cosmologies), and larger (~100 sq deg) volumes with less detail, one cosmology**
- **Very large volumes (~10,000 sq deg) with ~no galaxy properties beyond position and shear, with a range of cosmologies**
- **Long session on CatSim/PhoSim (led by Debbie/Simon)**

Mock Catalog Validation

- **Long list of possible observational measurements that can be compared to observations compiled by Joanne Cohn**
- **Use of catalogs determines which observations are most useful for validation**
- **Working group agreed that it will be very useful to have a common set of observational data that can be used by each group for validation**
- **Data format question for charging data: dictated by input format to CatSim (sql data base)**

Summary

- Work has started on different parts of our task lists
- Focus of Wednesday sessions on mock catalogs, requirements from other working groups
- Cross-working group sessions on IAs, modified gravity, covariances, photo-z, clusters, baryonic effects
- "Living" document on mocks will be made available on wiki, more input from analysis working groups very welcome!
- Two highlight projects for the next 12 months:
  - Improved mock catalogs
  - Set of prediction tools

Thanks to the Organizers!